

FRACTURING TEMPLATED CARBON NANOTUBES WITH A MEMS TESTING STAGE

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Abstract

An *in-situ* mechanics study on individual templated carbon nanotubes (T-CNTs) was conducted in a scanning electron microscope (SEM, LEO1525), using a MEMS-based tensile testing system.¹ The T-CNTs were made by pyrolyzing ethylene in alumina nanopore membranes.² The testing system is composed of a high aspect ratio MEMS device with an integrated thermal actuator and force sensing structures. The device provides well-controlled nanoscale displacement and force for loading nanostructures. Novel approaches have been developed to align and mount³ a T-CNT on the two opposing platforms of the testing stage (Figure 1). A fountain-pen writing technique was developed to deposit paraffin for quick clamping of the T-CNT in the SEM by electron beam induced deposition (EBID).

An increasing tensile load was applied to the T-CNT by moving the platform attached to the actuator away from the other platform. High-resolution SEM images were acquired while increasing the load on the T-CNT. The T-CNT eventually fractured without sliding. The diameter of the T-CNT was measured on the exposed fracture surface of the two fracture segments that remained attached to the platform (Figure 2). The load can be obtained from the deformation of the force-sensing beam integrated in the device. This force from the force-sensing beam is obtained through FEM modeling and further calibrated with an AFM cantilever operated by a home-built manipulator. Stress concentration due to a non-uniform diameter is speculated as being the cause of the location of fracture. The stress vs strain, Young's modulus, and tensile strength of several T-CNTs loaded in this way, are being characterized. The experiment suggests the potential use of this home-built testing stage for tensile loading of a variety of nanowires and nanotubes.

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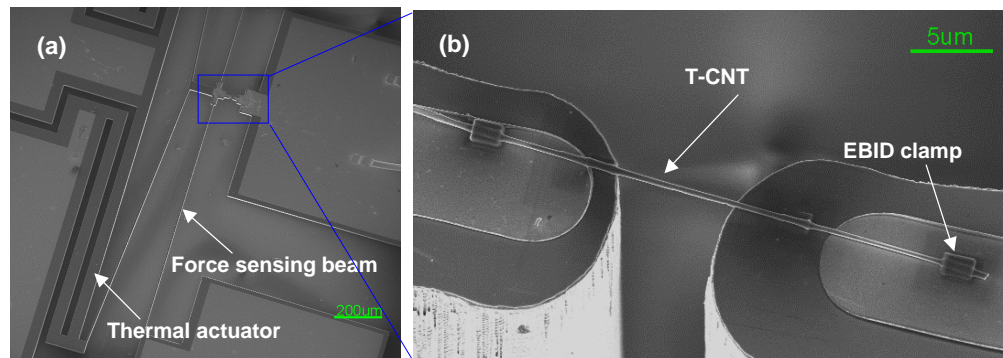


Figure 1. SEM images of: (a) MEMS testing stage; (b) a T-CNT aligned across the platforms (thus 100 μm above the bottom of the trench between the platforms) of the testing stage shown in (a), and clamped with EBID before being tensile loaded.

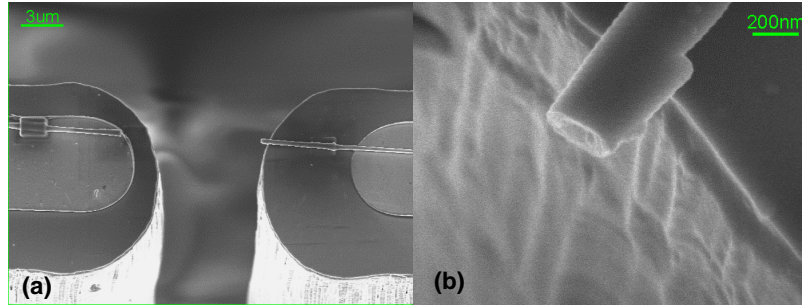


Figure 2. SEM images of: (a) the T-CNT after fracture; (b) one of the fracture surfaces of the T-CNT shown in (a).

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